Recent Top Quark Results from DØ

- *New Run II topological σ_{tt} measurement (in development)*
- *New method for extracting **t**-quark properties applied to Run I data:*
  - *Mass measurement*
  - *W helicity measurement*

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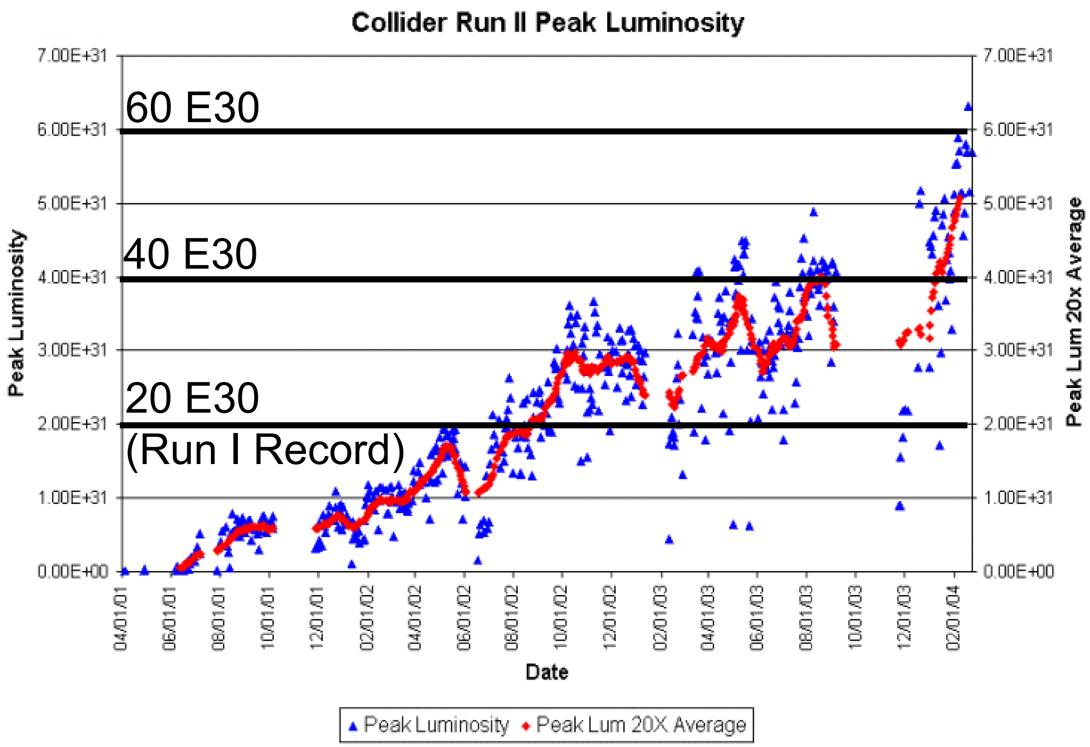
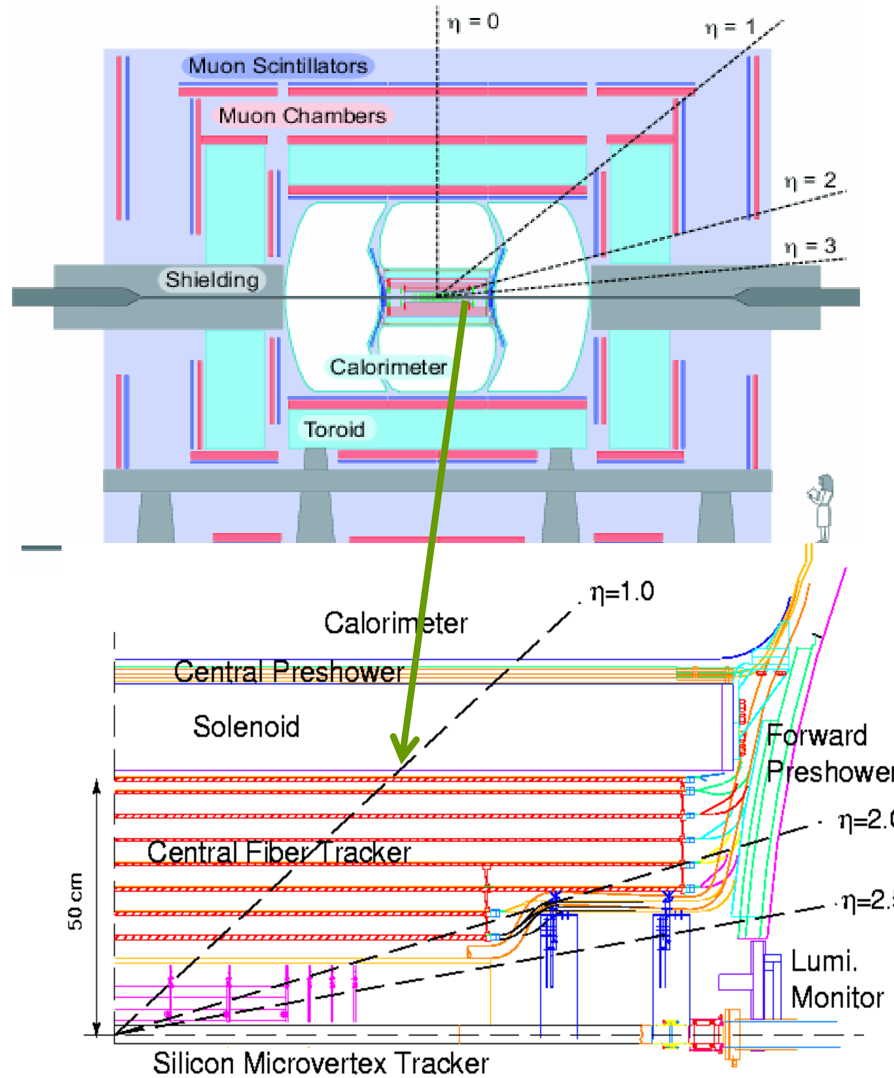
Top Production at RunII of Tevatron

- $p\bar{p}$ collider with center of mass energy 1.96 TeV
  - World's only source of top quarks
  - Production rate increased vs Run I
    - Higher energy ⇒ higher production cross-section (up ~30%)
    - Higher luminosity



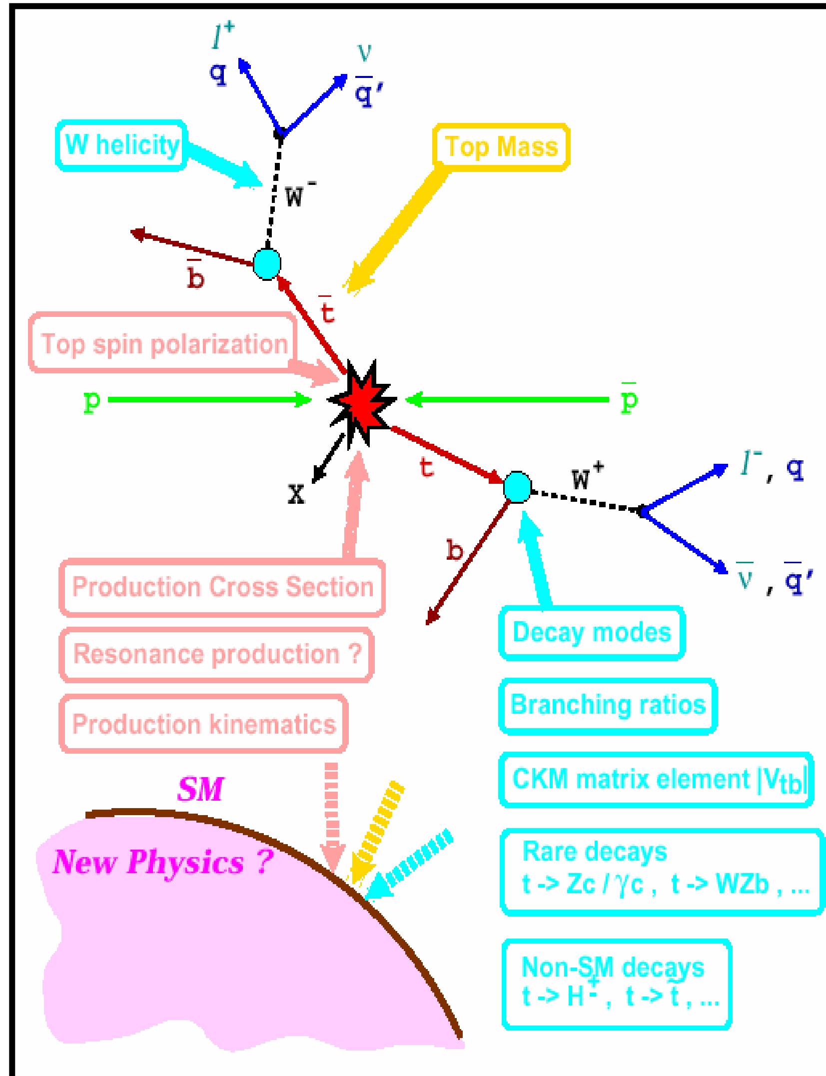
The Run II DØ Detector

- New central tracking inside 2 T solenoid
  - Silicon vertex detector
    - b-tagging
  - Scintillating fiber tracker
- New forward muon system
- New readout / trigger electronics



The RunII Dataset

- DØ has recorded dataset of 280 pb^{-1}
  - >2x bigger than sample used for top discovery
  - Expect to double again by end of 2004
  - Ultimately, ≥30X increase over Run I
- Sample in hand – exciting program of top physics underway:
  - Production: $t\bar{t}$ and single-top
  - Mass to higher precision
  - *W* polarization in *t* decay



Current Analysis Sample

- Just finished reprocessing 200 pb-1 of data from before Tevatron shutdown in autumn 2003
  - >520 million events processed at 6 global sites
  - Motivated by improvements in reconstruction code
    - New tracking algorithm
    - New alignment
    - Improved jet-finding algorithm

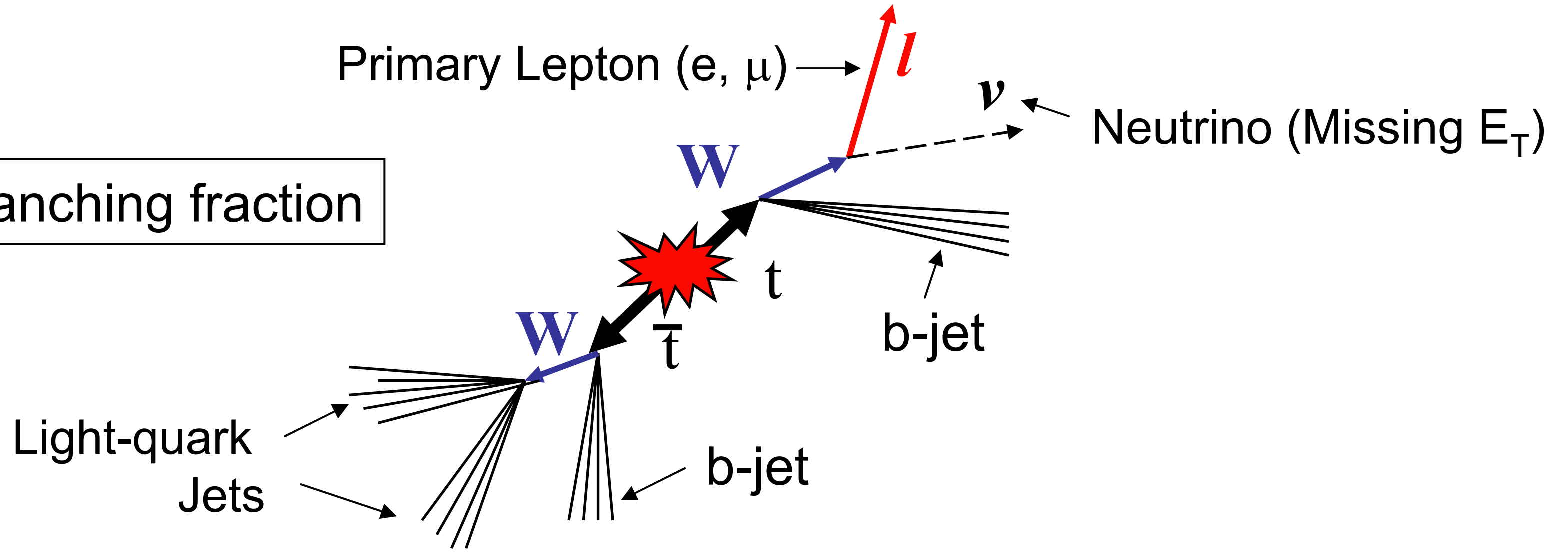
Benefits to top analyses:

- μ track-matching $\varepsilon \uparrow$ 20%
- EM likelihood $\varepsilon \uparrow$ 20%

- Begun a new top cross-section measurement
  - Using 140 pb-1
  - Conservative data quality criteria (precision measurements)
  - Expect to recover significant fraction of remaining data

Cross Section Measurement, ℓ+jets

~30% of branching fraction



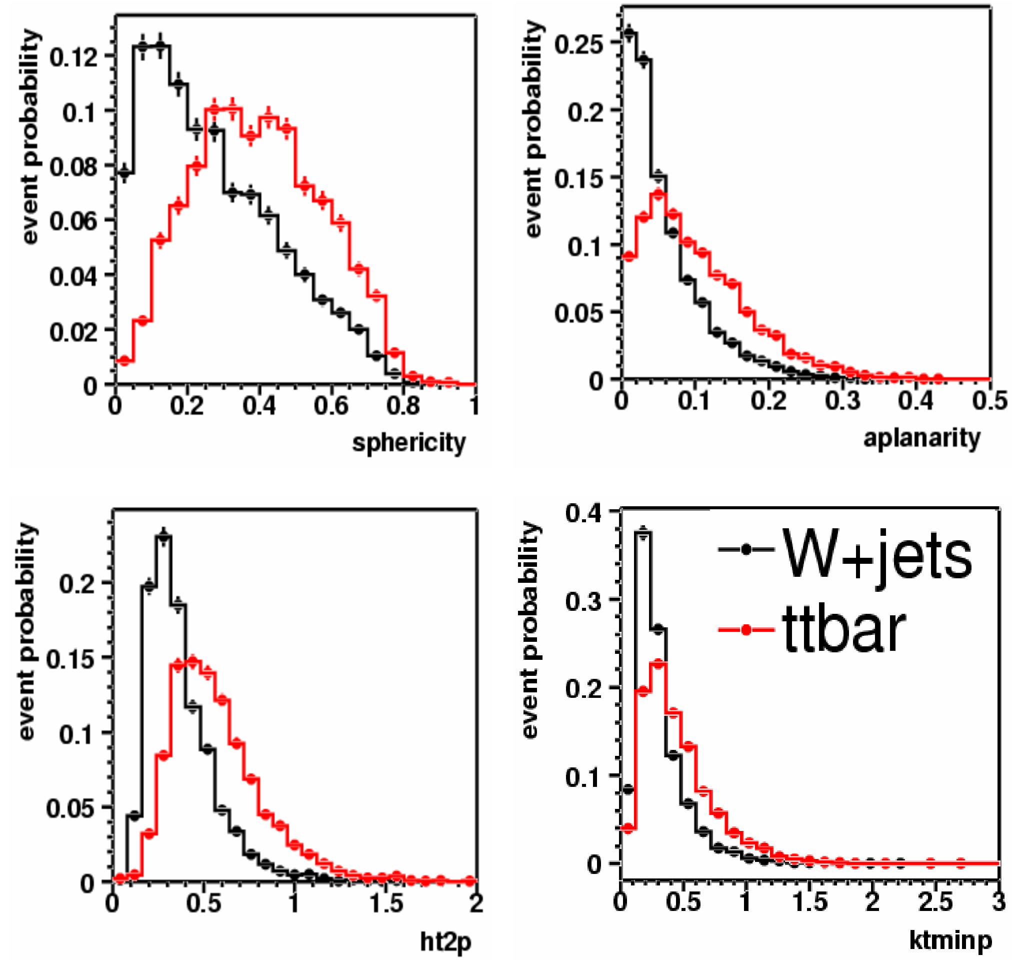
- Backgrounds
  - *W* + ≥4 jets production, leptonic *W* decay
  - QCD multijet production, heavy quark decay, fake lepton
- Analysis Strategy
  - Preselect sample enriched in *W*-like events
  - Use topological information to separate top from background

ℓ + jets Event Preselection

- Preselection
  - *e* or μ
    - p_T>20 GeV
    - $|\eta_e|$< 1.1, $|\eta_\mu|$< 2.0
    - Isolated from tracks and calorimeter energy
    - Consistent w/ primary vertex
  - Neutrino
    - $\not{E}_T$ > 20 GeV
    - $\not{E}_T$ neither along nor against lepton's direction
  - Jets
    - ≥4 jets, p_T > 15 GeV
- Remaining QCD Multijet
  - Exploit difference in lepton's environment to estimate this contribution
    - Leptons from QCD Multijet associated with jets
    - Leptons from top and *W* are similarly isolated
    - Study isolation in low and high $\not{E}_T$ samples

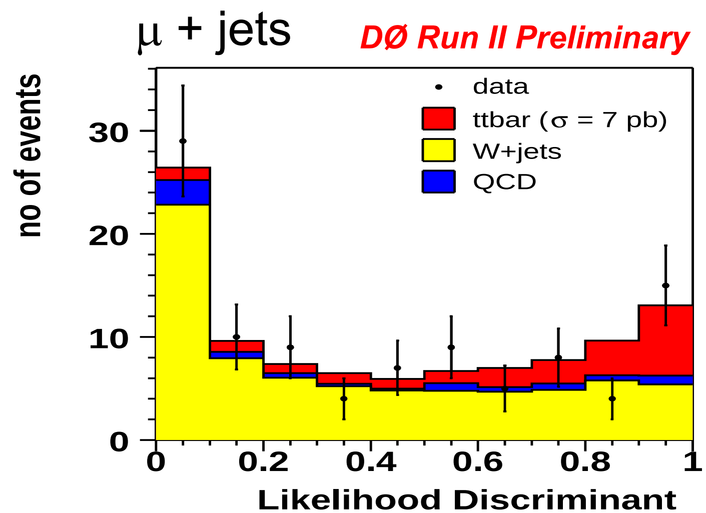
Topological Discrimination

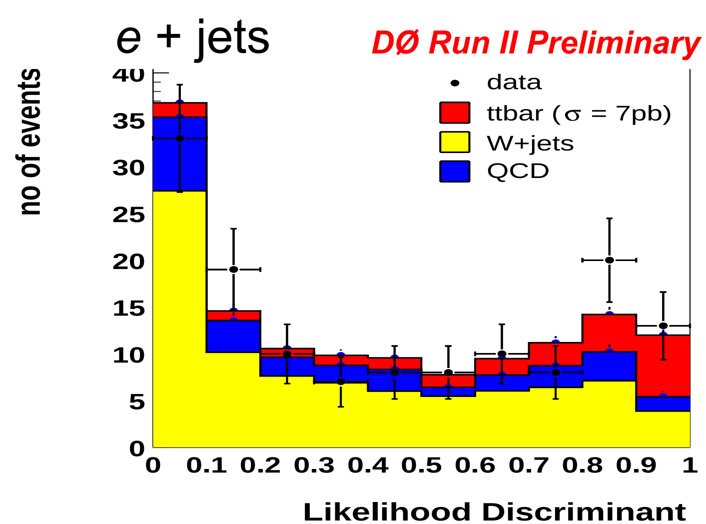
- Increasing statistical precision work to limit systematic uncertainty
  - Jet Energy Scale systematic dominates earlier results
- Use topological variables that depend on
  - Angular quantities
    - sphericity
    - aplanarity
  - Ratios of energy-dependent quatities
    - H'_{T2}
    - K'_{Tmin}



Likelihood Fit

- Build likelihood assuming variables uncorrelated
- Templates formed
  - Top, *W*+jets from MC
  - QCD from orthogonal data
- Signal and background yields to be extracted from likelihood fit
  - Fit would include constraint from evaluated QCD contribution
- Cross-section not yet ready
  - Working to understand background models to level necessary for precision measurement
  - Currently, top contribution fixed assuming σ_{tt} = 7 pb
  - QCD fixed to evaluated yield
  - W+jets set to make up the difference





New Run I Top Mass Measurement

- Fundamental parameter of SM
- Top mass constrains Higgs mass
- Precise measurement important after discovery of light Higgs
  - Consistency check of SM
- Run I DØ result (125 pb^{-1}, 1998):
  - $m_t = 172.1 \pm 7.1$ GeV/c^2
- Improved precision as sample increases
  - Expectation for 2 fb^{-1}: $\delta M_t \approx 3.0$ GeV using published method
  - In meantime more powerful method for mass analysis developed with Run I data
  - Make more optimal use of our growing dataset

Improved M_t Precision in ℓ + jets

- Preselection [*PRD 58 (1998), 052001*]
    - Isolated lepton: E_T>20 GeV,$|\eta_e|$<2,$|\eta_\mu|$<1.7
    - Jets: $\geq$4, E_T>15 GeV, $|\eta|$<2
    - Missing E_T > 20 GeV
    - $|E_T^{lep}| + |\not{E}_T| > 60$ GeV ; $|\eta_W| < 2$
  - 91 events selected
- 1998 approach
  - Choose lowest χ^2 solution from constrained kinematic fit → fitted mass
  - Topological discriminant used to separate signal and background
  - Mass estimate made with 2D fit in fitted mass and discriminant
- 2003 analysis
  - Begin with same event selection, also require exactly 4 jets
    - 71 events
  - Estimate mass using ***event probabilities***

Improved Measurement: Method

- Probability density

$$P(x, M_t) = \frac{1}{\sigma(x)} \int d\sigma(y, M_t)\, dq_1\, dq_2\, f(q_1) f(q_2) W(y, x)$$

Mass-dependent, x : reconstructed 4-vectors

Differential Xsec (LO Matrix element + phase space)

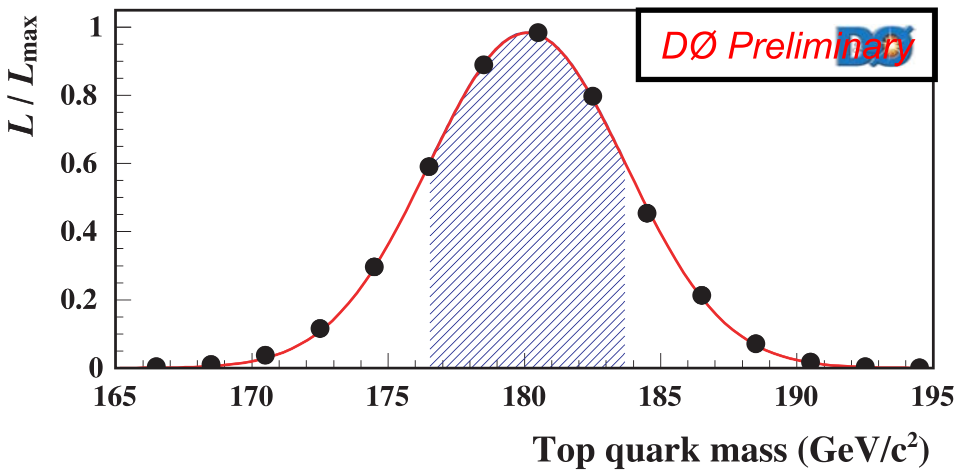
PDF's

Transfer function Relating partonic Variables to Measured quantities

- All jet-parton assignments considered
  - Sum probabilities of all possibilities (12 total)
  - Correct assignment always used
- Background probability
  - Main component W+jets (85% of background)
  - P_{bkg} calculated from leading order matrix element from VECBOS
- Signal purity increased with cut on background probability: $P_{bkg} < 10^{-11}$
  - 22 events remain

Result

- Event probability: $P(x;c_1,c_2,M_t) = c_1 P_{t\bar{t}}(x;M_t) + c_2 P_{bkgd}(x)$
  - Likelihood formed, maximized to obtain M_t, c1, c2



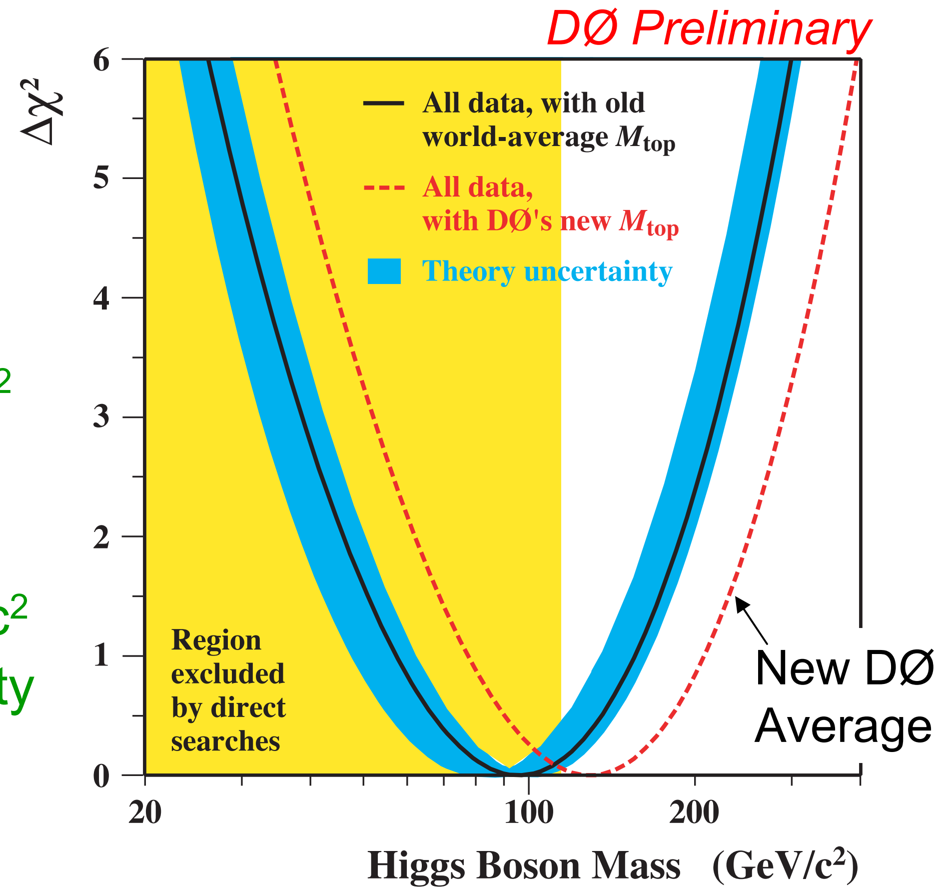
DØ Preliminary

M_t = 180.1 ± 3.6 (stat) ± 3.9 (syst) GeV/c^2 = 180.1 ± 5.3 GeV/c^2

- 12 signal, 10 background events
- Improvement in statistical uncertainty equivalent to 2.4 times more data…
- Dominant systematic error from JES (3.3 GeV/c^2)

New Run I Mass Result and Higgs

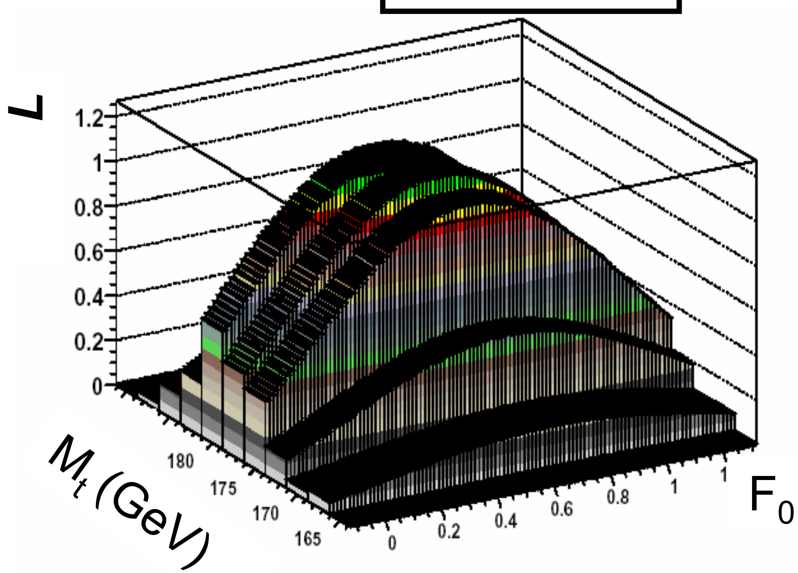
- When combined with previous DØ dilepton measurement, new DØ combined mass:
  - $M_t = 179.0 \pm 5.1$ GeV/c^2
- Global fit to electroweak data using this top mass
  - Method of LEPEWWG (hep-ex 0312023)
  - Best-fit $M_H \approx 123$ GeV/c^2
  - 95% C.L. upper limit 277 GeV/c^2
- Solid line old world average
  - $M_t = 174.3 \pm 5.1$ GeV/c^2
  - $M_H \approx 96$ GeV/c^2, U.L. 219 GeV/c^2
  - Blue curve theoretical uncertainty
- Yellow: excluded region
  - $M_H < 114.4$ GeV/c^2 @95% CL



Run I W Helicity Measurement

- The top decays before hadronization can occur
  - Spin information transferred to daughters (*Wb*)
  - SM: top decays via V-A current
    W polarization for M_t = 175
    - 70% Longitudinal (F_0)
    - 30% Left-handed(F_-)
  - Angular distribution of decay products in W rest frame probes this mixture
- Same dataset, probability-based approach: allow F_0 to vary
- Result is statistics limited
  - Should provide increased sensitivity with more data

DØ Preliminary



DØ Preliminary

$$F_0 = 0.56 \pm 0.31 \text{ (Statistical)} \pm 0.04 \text{ (Systematic)}$$

Summary and Outlook

- Updated topological σ_{tt} measurement in lepton + jets channel
  - Will make use of likelihood fits to topological discriminant
  - ~140 pb^{-1} of newly reprocessed Run II data
  - Complete result on the way
- Many other updates in progress with this sample
  - Cross section – dileptons, b-tagged ℓ + jets, all jets
  - Top mass and W helicity measurements
  - Single-top search
- Improved method for extracting top quark properties
  - Run I mass and W helicity results
  - Approach will allow for better use of a growing dataset

Extra Slides

Determining QCD Multijet Yield

loose	muon isolation $\longrightarrow$ electron likelihood cut	tight

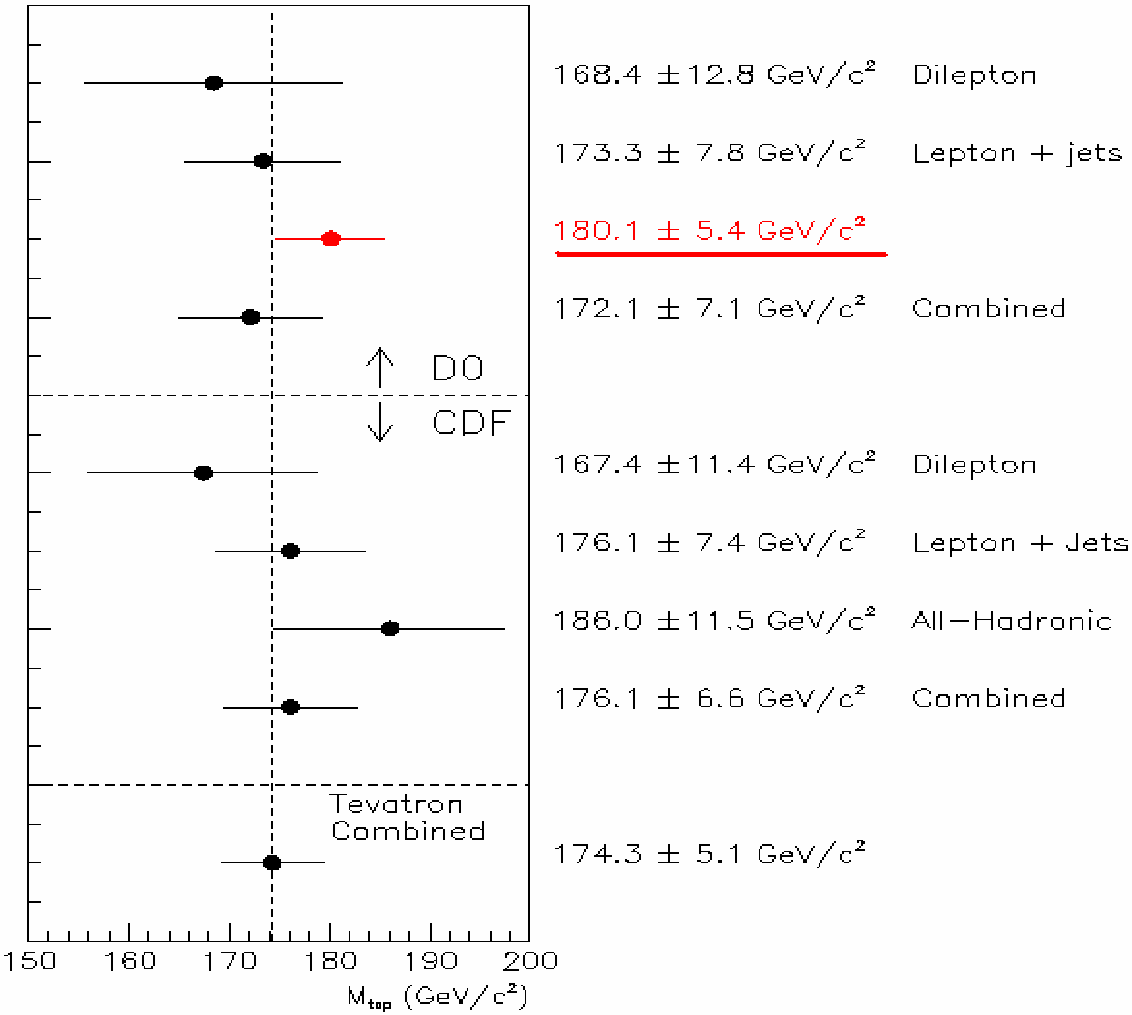
$$N_l = N_{QCD} + N_{W+ttbar}$$
$$N_t = \varepsilon_{QCD} * N_{QCD} + \varepsilon_{W+ttbar} * N_{W+ttbar}$$

- *N_l and N_t are measured in the signal data sample*
- *ε_{QCD} is estimated from an independent QCD data sample, requiring the same preselection, but low missing ET and low W ET*
- *$\varepsilon_{W+ttbar}$ is estimated from W+jets MC and scaled to W+jets data by using Z events:*
  $SF = \varepsilon_{Z\text{->}ll \text{ in data}} / \varepsilon_{Z\text{->}ll \text{ in MC}}$
- *Solve this linear System of second order for the two missing unknowns: N_{QCD} and $N_{W+ttbar}$*

Topological Variable Definitions

- Sphericity: summed p^2_T with respect to event axis
  - Dijet event – S ≈ 0, isotropic event – S ≈ 1
- Aplanarity: measure of ‘flatness’ of event
  - Large values indicate spherical events
- H'_{T2}: measures event centrality
  - H_{T2} – scalar sum of jet p_T’s (excluding leading jet)
  - H_{T2}/H_z – larger for central events
- K'_{Tmin} : measure of minimum jet p_T in closest pair
  - Tends to be small for soft & colinear backgrounds

New Run I Mass Result



The relative error in this result is 3%, compare to 2.9% from the previous CDF and DØ combined average for all channels.